
Emergency Action Planning for Dam Safety

Course No: C04-054

Credit: 4 PDH

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Federal Guidelines for Dam Safety

Emergency Action Planning for Dams

FEMA 64 / July 2013



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PREFACE

The Federal Emergency Management Agency (FEMA) is responsible for coordinating the Federal response to disasters and for providing Federal guidance to State, local, Tribal, and Territorial emergency management authorities for all foreseeable emergencies in the United States and U.S. Territories. To improve the Nation's emergency preparedness and response capabilities, FEMA believes that formal guidelines are needed to help dam owners, in coordination with emergency management authorities, effectively develop and exercise Emergency Action Plans (EAPs) for dams. The purpose of the guidance in this document is to meet that need. This document is an update of FEMA 64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners* (2004).

Background

In "Dam Safety Memorandum to the Heads of Certain Federal Agencies," dated April 23, 1977, President Jimmy Carter directed that (1) dam safety reviews of various Federal programs be documented, (2) the chair of the Federal Coordinating Council for Science, Engineering, and Technology convene an ad hoc interagency committee provide "recommendations as to the means of improving the effectiveness of the Government-wide dam safety effort" and prepare and report on "proposed Federal dam safety guidelines for management procedures to ensure dam safety," and (3) the Executive Office of Science and Technology Policy arrange for a panel of recognized experts to review agency regulations, procedures, and practices throughout the Federal Government and to review proposed Federal dam safety guidelines. The panel was to advise the President in a report due October 1, 1978, on whether the regulations, procedures, practices, and guidelines were adequate for ensuring the safety of dams.

Executive Order 12148, Federal Emergency Management, issued on July 20, 1979, transferred or reassigned to FEMA the management of emergency planning and assistance functions that had been vested in the President. At that time, FEMA was a new agency, having been established under the Reorganization Plan No. 3 of 1978. In addition to providing that FEMA "establish Federal policies for, and coordinate, all civil defense and civil emergency planning, management, mitigation, and assistance functions of Executive agencies," Executive Order 12148 made FEMA responsible for coordinating efforts to promote dam safety.

On October 4, 1979, President Carter issued a Presidential memorandum directing certain Federal agencies to implement FEMA 93, *Federal Guidelines for Dam Safety*, and to report their implementation progress to FEMA. Consequently, FEMA established the Interagency Committee on Dam Safety (ICODS) to encourage the establishment and maintenance of effective Federal programs, policies, and guidelines for dam safety. FEMA 93 encourages strict safety standards in the practices and procedures of Federal agencies and dam owners regulated by Federal agencies. The guidelines state that "Those charged with administering the guidelines must recognize that the achievement of dam safety is through a continuous, dynamic process in which guidelines, practices, and procedures are examined periodically and updated."

In 1996, the Water Resources Development Act of 1996 (Public Law 104-303) directed FEMA to establish a National Dam Safety Program, transferred additional dam safety functions to FEMA, and authorized the establishment of ICODS as a permanent advisory body. The Act also directed FEMA to establish a National Dam Safety Review Board whose purpose would be to advise the Director of FEMA (now referred to as the Administrator) on setting national dam safety priorities and to provide assistance in monitoring State dam safety programs.

With the advice of the National Dam Safety Review Board and encouragement of ICODS, FEMA has developed and updated the following Federal guidelines to supplement FEMA 93:

- FEMA 64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners* (renamed with this update FEMA P-64, *Federal Guidelines for Dam Safety: Emergency Action Planning for Dams*)
- FEMA 65, *Federal Guidelines for Dam Safety: Earthquake Analyses and Design of Dams*
- FEMA 94, *Federal Guidelines for Dam Safety: Selecting and Accommodating Inflow Design Floods for Dams*
- FEMA 148, *Federal Guidelines for Dam Safety: Glossary of Terms*
- FEMA 333, *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams*

In 2010, the National Dam Safety Review Board's Work Group on Emergency Action Planning for Dams established a Task Group to review the 2004 edition of FEMA 64 and to make recommendations for updating the guidelines. This document, the 2013 edition of FEMA 64, is an update of the 2004 edition. The updates include the addition of approaches and practices that are consistent with the National Response Framework and with emergency action planning concepts from a variety of contemporary sources. The updates reflect the consensus of the Task Group and have been approved by the ICODS and the National Dam Safety Review Board.

The goal of the updated guidelines is to encourage (1) the development of comprehensive and consistent emergency action planning to protect lives and reduce property damage and (2) the participation of emergency management authorities and dam owners in emergency action planning.

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Acronyms and Abbreviations

AAR	After Action Report
DHS	Department of Homeland Security
EAP	Emergency Action Plan
EOC	Emergency Operations Center
FEMA	Federal Emergency Management Agency
HSEEP	Homeland Security Exercise and Evaluation Program
ICODS	Interagency Committee on Dam Safety
ICS	Incident Command System
IDF	Inflow Design Flood
NID	National Inventory of Dams
NIMS	National Incident Management System
NWS	National Weather Service
PIO	Public Information Officer
PMF	Probable Maximum Flood
WFO	Weather Forecast Office

I. BASIC CONSIDERATIONS FOR PREPARING AN EMERGENCY ACTION PLAN

A. Purpose

1. General

Residents of areas that could be affected by a dam failure or operational incident have a risk of loss of life, injuries, and damage to property from a failure or operational incident. The purpose of this document is to provide guidelines for the preparation of an Emergency Action Plan (EAP) to facilitate the development of plans that are comprehensive and consistent. The purpose of an EAP is to protect lives and reduce property damage.



Flooding caused by the failure of Teton Dam in eastern Idaho as it was filling for the first time (1976); 14 people died (waterarchives.org)

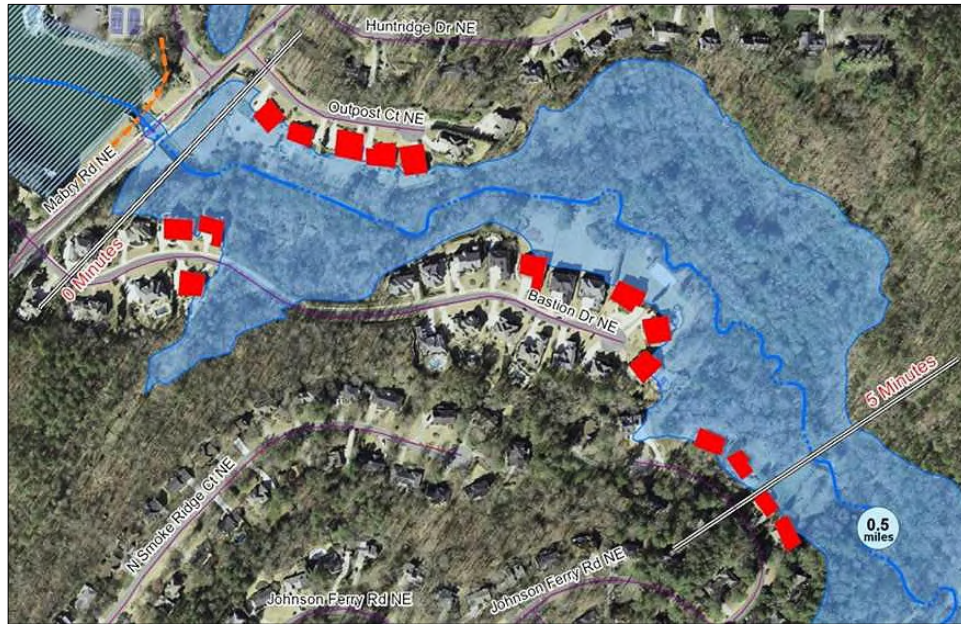
The intended readers of this document are dam owners and emergency management authorities who work together in the response to dam safety emergencies.

An EAP is a formal document that identifies potential emergency conditions at a dam and specifies actions to be followed to minimize loss of life and property damage. The EAP includes:

- Actions the dam owner will take to moderate or alleviate a problem at the dam
- Actions the dam owner will take, and in coordination with emergency management authorities, to respond to incidents or emergencies related to the dam
- Procedures dam owners will follow to issue early warning and notification messages to responsible downstream emergency management authorities
- Inundation maps to help dam owners and emergency management authorities identify critical infrastructure and population-at-risk sites that may require protective measures, warning, and evacuation planning
- Delineation of the responsibilities of all those involved in managing an incident or emergency and how the responsibilities should be coordinated

2. Dam Safety Incidents and Emergencies

A dam safety incident is an impending or actual sudden uncontrolled release or excessive controlled release of water from an impounding structure. The release may be caused by damage to or failure of the structure, flood conditions unrelated to failure, or any condition that may affect the safe operation of the dam. The release of water may or may not endanger human life, downstream property, or the operation of the structure.



Projected flooding from a breach in a dam in a residential area

When people live in an area that could be affected by the operation or failure of a dam, there is the potential for an emergency related to a dam safety incident. The National Incident Management System (NIMS) defines an emergency as “any incident, whether natural or manmade, that requires responsive action to protect life or property.” The Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, as amended (42 U.S.C. §§ 5121–5206), defines an emergency in terms of the Federal response (“any occasion or instance for which, in the determination of the President, Federal assistance is needed to supplement state and local efforts and capabilities to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe in any part of the United States”).

3. Uniformity of Emergency Action Plans

EAP effectiveness can be enhanced by a uniform format that ensures that all critical aspects of emergency planning are covered in each plan. Uniform EAPs and advance coordination with emergency management authorities should facilitate a timely response to a developing or actual emergency. Organizations and individuals who own or are responsible for the operation and

maintenance of dams are encouraged to use these guidelines to develop, update, revise, and exercise their EAPs.

4. National Incident Management System

NIMS provides a systematic, proactive approach to guide all levels of governmental, nongovernmental, and private-sector organizations to work seamlessly to respond to incidents. The NIMS approach is effective for any situation that involves coordination among multiple agencies or partners. The goal is to coordinate activities to reduce consequences (loss of life, property damage, and harm to the environment).

The Incident Command System (ICS) is a fundamental element of NIMS and consists of a standardized, on-scene, all-hazards incident management approach that:

- Allows for the integration of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure
- Enables a coordinated response among various jurisdictions and functional agencies, both public and private
- Establishes common processes for planning and managing resources

As a system, ICS is extremely useful. The ICS provides an organizational structure for incident management and guides the process for planning, building, and adapting that structure. Using ICS for every incident or planned event helps hone and maintain skills needed for larger scale incidents. It is recommended that dam owners coordinate with appropriate emergency management authorities in an effort to incorporate ICS and NIMS concepts and structures into the EAP.

A critical tool for promoting the nationwide implementation of NIMS is a well-developed training program. For further information on NIMS training courses, dam owners and emergency management authorities should contact the appropriate State and/or local response agencies and refer to FEMA's website at www.fema.gov.

B. Scope

The EAP guidelines in this document are focused on developing or revising EAPs for dams that would likely cause loss of life or significant property damage as a result of a failure or other life-threatening incident. The areas downstream of each dam are unique. Therefore, the extent and degree of potential impacts of each dam vary.



Flooding in Cedar Rapids, Iowa, including this hospital from overtopping of the spillway at Coralville Dam as a result of heavy rains (2008)

The level of detail in the EAP should be commensurate with the potential impact of a dam failure or operational incident. A dam with low or no potential impact should not require an extensive evaluation or be subject to an extensive planning process while high- and significant-hazard dams may require a larger emergency planning effort. In addition, high- and significant-hazard dams tend to involve more entities that must coordinate responsibilities and efforts to effectively respond to an incident than low-hazard dams. Every EAP must be tailored to the site conditions.

EAPs generally contain six elements:

- Notification flowcharts and contact information
- Response process
- Responsibilities
- Preparedness activities
- Inundation maps
- Additional information in appendices

The elements of an EAP are described in Chapter II of these guidelines. All elements should be included in a complete EAP. Although the dam owner is responsible for developing and maintaining the EAP, the plan will not be effective unless it is developed and implemented in close coordination with all applicable emergency management authorities. Emergency management authorities will use the information in the dam owner's EAP to facilitate the implementation of their responsibilities. In general, State and local emergency management authorities will have some coordinating plans in place to address local emergency operations and/or warnings and evacuations.

C. Coordination

It is vital that the development of the EAP be coordinated with all entities, jurisdictions, and agencies that would be affected by an incident at the dam or that have statutory responsibilities for warning, evacuation, and post-incident actions. The EAP should contain clearly defined roles and responsibilities for each entity.

Coordination with emergency management authorities responsible for warning and evacuating the public is essential for ensuring agreement on individual and group responsibilities.

Participation in the development of the EAP will enhance confidence in the EAP and its accuracy. Coordination will provide opportunities to discuss critical emergency planning concerns such as the order of public official notification, use of backup personnel, alternate means of communication, and special procedures for nighttime, holidays, and weekends.

To ensure a timely and accurate information exchange, coordination between the dam owner, local emergency management authorities, and the appropriate National Weather Service (NWS) Weather Forecast Office (WFO) is highly recommended. The NWS has a congressional mandate to issue official public warnings for all weather-related events, including dam breaches and flooding. The planning process should include a decision about who will contact the NWS. The local emergency authority is recommended unless it is otherwise agreed to by the emergency authority and dam owner. Local NWS websites (www.weather.gov) provide links to local WFOs, a description of NWS services, and a list of NWS products.

Coordination with upstream and downstream dam owners is important to determine operational procedures for mitigating the effects of floods and dam safety emergencies. Dams that provide critical resources to a community should have a recovery plan that was developed in coordination with local emergency management authorities. The loss of a dam that provides a key resource such as power or drinking water could significantly affect the recovery of a community or region. Recovery and continuity of operations of critical infrastructure for these types of dams are discussed in *Dams Sector Crisis Management Handbook: A Guide for Owners and Operators* (DHS, 2008), available at www.dhs.gov/dams_sector_crisis_handbook.pdf.

D. Evacuation

Evacuation planning and implementation is typically the responsibility of State or local emergency management authorities.

Although an EAP does not need to include an evacuation plan, it should indicate who is responsible for evacuation and whose plan will be followed.

Inundation maps developed by the dam owner must be shared with emergency management authorities and included in the EAP (see Figure 1 on page II-19 for an example of an inundation map). These maps may help in the development of warning and evacuation plans. It is important for



Voluntary evacuation because of flooding (North Dakota, 2009)

dam owners to coordinate with the appropriate emergency management authorities and provide information from dam inundation studies that can assist with evacuation planning.

Dam owners should also include procedures in the EAP for ensuring that emergency management authorities are provided with timely and accurate information on dam conditions during an incident. This information will help agencies make the appropriate decisions on evacuations.

Dam emergency evacuation plans should be developed before an incident occurs. The plans are recommended to be based on a worst-case scenario and to address the following:

- Initiation of emergency warning systems
- Pre-incident planning
- Identification of critical facilities and sheltering
- Evacuation procedures, including flood wave travel time considerations (e.g., evacuation of special needs populations, lifting evacuation orders)
- Distance and routes to high ground
- Traffic control measures and traffic routes
- Potential impact of weather or releases on evacuation routes such as flooded portions of the evacuation route before the dam incident occurs
- Vertical evacuation/sheltering in place
- Emergency transportation
- Safety and security measures for the perimeter and affected areas
- Re-entry into affected areas



Planning session

E. Document Control and Protection of Critical Information

The dam owner should develop an EAP distribution list for all those who would be involved in implementing the EAP. The list must be reviewed and updated as part of updates to the EAP. Each copy of the EAP that is distributed should be controlled by copy number and a notice requesting that other copies of the EAP not be made. When outdated EAPs have been replaced in their entirety with new versions, the dam owner should request that the outdated controlled copies be returned to the owner or otherwise ensure they are securely destroyed to prevent

misuse. If EAPs are made available electronically, care should be taken to ensure that document control is maintained, such as through the use of a secure web portal accessible only to the entities on the established distribution list.

To protect critical information, including but not limited to technical data and personal contact information, dam owners should consider maintaining a redacted copy of the EAP. The redacted copy made available to the public upon request should not contain, for example, detailed technical data or contact information of individuals participating in the EAP. Dam owners may also wish to limit the technical information provided to external entities participating in the EAP. Decisions about what to include in the redacted copy should be made by those participating in the EAP.

F. Maintaining an EAP

After the EAP has been developed, approved, and distributed, continual reviews and updates must be performed. Without periodic maintenance, the EAP will become outdated and ineffective.

The EAP should be updated promptly to address changes in personnel and contact information, significant changes to the facility, or emergency procedures. The EAP should be reviewed at least annually for adequacy and updated as needed. Even if no revisions are necessary, the review should be documented.

The review should include an evaluation of any changes in flood inundation areas, downstream developments, or in the reservoir and a determination of whether any revisions, including updates to inundation maps, are necessary. Appendix A contains an EAP review checklist.

The EAP should be updated promptly with the outcome of any exercises, including periodic reviews and verifications of personnel and contact information from Notification Flowcharts and contact lists. Any changes to the dam and/or inundation zone should be reviewed because the changes may affect the inundation maps. Maps should be changed as soon as practicable and noted in the EAP.

Once the EAP has been revised, the updated version (or only the affected pages in minor updates) should be promptly distributed to those on the distribution list. Placing EAPs in loose-leaf binders may simplify the process of removing and replacing outdated pages when updates are made. Including the date of the EAP or the date of the current revision on each page will help to ensure that users have the most current version. It is recommended that the entire EAP be reprinted as necessary and distributed to all plan holders to ensure that all updates have been included in the documents.

II. SUGGESTED EAP OUTLINE AND CONTENTS

A. Suggested EAP Outline

A suggested EAP outline is provided below. Considering all of the items in the outline will ensure that the six EAP elements identified in Chapter I of this document are included, thus providing uniform, comprehensive, and consistent dam emergency action planning. It is also important that the dam owner, emergency management authorities, and regulatory requirements be incorporated into the EAP. The development of the EAP should be coordinated with the appropriate authorities and organized in a format that is most useful to, and consistent with, the organizations involved with its implementation.

Front Matter

- Cover

- Title Page

- Table of Contents

- EAP Signatures

Part I: EAP Information

- I. Summary of EAP Responsibilities

- II. Notification Flowcharts

- III. Statement of Purpose

- IV. Project Description

- V. EAP Response Process

 - Step 1: Incident Detection, Evaluation, and Emergency Level Determination

 - Step 2: Notification and Communication

 - Step 3: Emergency Actions

 - Step 4: Termination and Follow-up

- VI. General Responsibilities

 - Dam Owner Responsibilities

 - Notification and Communication Responsibilities

 - Evacuation Responsibilities

 - Monitoring, Security, Termination, and Follow-up Responsibilities

 - EAP Coordinator Responsibilities

- VII. Preparedness

 - Surveillance and Monitoring

 - Evaluation of Detection and Response Timing

 - Access to the Site

 - Response during Periods of Darkness

- Response during Weekends and Holidays
- Response during Adverse Weather
- Alternative Sources of Power
- Emergency Supplies and Information
- Stockpiling Materials and Equipment
- Coordination of Information
- Training and Exercise
- Alternative Systems of Communication
- Public Awareness and Communication

VIII. Inundation Maps

Part II: Appendices

The suggested format separates the EAP into two parts: the basic EAP instructions (EAP Information) and supporting information (appendices). The content and depth of detail in the EAP should be appropriate for the risk the dam poses and meet the relevant regulatory requirements.

1. Part I: EAP Information

Sections I through VIII contain information that is likely to be used by all parties (dam owner and emergency management authorities) during an actual incident.

2. Part II: Appendices

The appendices should contain supplementary information. The appendices typically include material that was used to develop the EAP and information that can be used to assist with decision-making during an incident (e.g., detailed operation and maintenance requirements, dam break information and analyses, record of plan reviews and updates, plan distribution list, incident tracking forms).

When developing the appendices, dam owners, in coordination with emergency management authorities, should consider including supporting information that will help them respond rapidly and effectively to an incident.

B. Suggested EAP Contents

The suggested contents of the EAP are described in this section.

1. Front Matter

a. Title Page

The EAP title page identifies it as an Emergency Action Plan and specifies the dam for which it was developed. Both the dam and reservoir names should be included. If the dam has a State, National Inventory of Dams (NID), or other identifying number, it should be included. Other suggested information includes the dam owner's name or organization and, if applicable, a street address or location of the dam site.

b. Table of Contents

The table of contents should list all major sections of the EAP and the figures, tables, and maps.

c. EAP Signatures

The EAP should be signed by all parties involved in plan implementation to ensure that everyone is aware of the plan and understands the agreed-upon responsibilities.

2. Part I: EAP Information

a. Summary of EAP Responsibilities

Part I, Section I, of the EAP should summarize the critical responsibilities for responding to an incident and implementing the plan. Appendix B, Table B-1, is an example of a table with the general responsibilities of those involved with implementation of an EAP. Appendix B, Table B-2, is an example of a summary of dam owner responsibilities. During an actual incident, these types of summaries can provide quick and easy references to critical activities involved with implementing the EAP.

b. Notification Flowcharts

A Notification Flowchart identifies who is to be notified of a dam safety incident, by whom, and in what order. An example Notification Flowchart is provided in Appendix C. The information on the flowchart is critical for the timely notification of those responsible for taking emergency actions. For ease of use during an incident, the EAP should include Notification Flowcharts that clearly present the information listed below. One chart or a set of charts may be needed depending on the complexity of the hazards associated with the dam and the potentially affected downstream areas.

- Emergency level of the Notification Flowchart if more than one flowchart is required
- Individuals who will notify dam owner representatives and/or emergency management authorities
- Prioritization of notifications

- Individuals who will be notified

The Notification Flowchart should include appropriate contact information such as names, positions, telephone numbers, and radio call numbers. Supplemental contact information may be included in a list or table of emergency contacts. Supplemental contact information may include fax numbers, e-mail addresses, direct connect numbers, and alternate contacts. The Notification Flowchart may also be supplemented by NIMS ICS Forms, such as ICS Forms 205 and 205a, available at www.training.fema.gov/EMIWeb/IS/ICSResource/icsforms.htm.

The Notification Flowchart must be tailored to the needs and notification priorities of each dam. It is usually recommended that one person be responsible for contacting no more than three or four other parties. At a minimum, the Notification Flowchart should designate who dam owners will contact and who the local emergency management authorities will contact, as described below.

Dam owners will contact:

- Engineer/management staff/public affairs officer
- Local emergency authorities or 911 centers
- State dam safety program representatives
- Other regulatory authorities
- Upstream and downstream dam owners

Local emergency management authorities will contact:

- Other local responders such as police or fire
- State emergency management authorities
- Affected residents and businesses
- Appropriate NWS WFO



Mobile command center

If an emergency dispatch center is on the flowchart, a direct contact number for the center should be included because it may be necessary to contact emergency response authorities directly. In addition, it is possible that the caller may be outside the dispatch center's call range. For example, 911 calls made from a dam owner's operations center may not go to the same jurisdiction where the dam is located.

Notification Flowcharts should be easy to follow for each emergency level and should

allow for information to be exchanged upward and downward between the contacts. One flowchart that represents all emergency levels is preferred for simplicity. However, it may be necessary to develop a flowchart for each emergency level for clarity. Color coding may also be helpful. If necessary, narrative information supplementing the flowchart may be provided on the page following the flowchart. An example Notification Flowchart is provided in Appendix C.

If other forms of mass communication or notification are used, these may need to be incorporated into the Notification Flowchart and associated procedures. Examples include warning sirens, loud speakers, conference calling, mass e-mail notifications, and text messaging.

c. Statement of Purpose

The EAP should include a brief statement describing the purpose of the EAP. Two examples are provided below.

Example 1: "This Emergency Action Plan defines responsibilities and provides procedures designed to identify unusual and unlikely conditions that may endanger Alpha Dam in time to take mitigating action and to notify the appropriate emergency management authorities of possible, impending, or actual failure of the dam. The plan may also be used to provide notification when flood releases can create major flooding."

Example 2: "The purpose of this EAP is to safeguard the lives and reduce damage to the property of the citizens of Alpha County living along Beta Creek, in the event of failure of the Beta Creek Dam or flooding caused by large runoff."

d. Project Description

A description of the dam, its location, and the NID identification number should be provided in this section. If the NID identification number is not available, the State identification number should be used. A dam vicinity map and a simple drawing showing the dam's features are recommended, along with a list of any significant upstream or downstream dams and

downstream communities potentially affected by a dam failure or by flooding as a result of large operational releases. The dam owner should redact design information and site-specific concerns in EAP copies that are distributed to outside organizations if the organizations do not need the information to implement the plan.

e. EAP Response Process

There are generally four steps that should be followed when an unusual or emergency incident is detected at a dam. These steps constitute the EAP response process. The steps are:

- Step 1: Incident detection, evaluation, and emergency level determination
- Step 2: Notification and communication
- Step 3: Emergency actions
- Step 4: Termination and follow-up

Early detection and evaluation of the condition(s) or triggering event(s) that initiate or require an emergency response action are crucial. It is important to develop procedures for reliable and timely determination of an emergency level to ensure that the appropriate response actions are taken based on the urgency of the situation. Procedures for early notification are required to allow all entities involved with plan implementation to respond appropriately. Preventive or mitigating actions can be taken to attempt to address conditions at the dam. Eventually, a determination will need to be made concerning termination of the incident. After the incident is over, follow-up activities may be required. All of these steps make up the general EAP response process and should be discussed in the plan.

Step 1: Incident Detection, Evaluation, and Emergency Level Determination

During Step 1, an unusual condition or incident is detected and confirmed.

Unusual condition or incidents are unique to each dam and, to the extent possible, should be identified in the EAP. The following information should be considered for inclusion or reference in the plan to assist the dam owner in this step:

- Measures for detecting existing or potential failures
- Operating information, such as normal and abnormal reservoir level data
- Description of monitoring equipment, such as water level sensors and early warning systems
- Monitoring and instrumentation plans
- Inspection procedures
- Process for analyzing and confirming incoming data

After an unusual condition or incident is detected and confirmed, the dam owner will categorize the condition of incident into one of the established emergency levels based on the severity of the initiating condition or triggering events. Both the dam owner and emergency management authorities should understand the emergency levels and each other's expected responses. Consistency of the emergency level categories is recommended to eliminate confusion for emergency responders whose jurisdiction contains multiple dams and dam owners.



Piping flow through the dam as a result of dam concrete failure

The four dam safety emergency level categories listed below are recommended. However, dam owners, in coordination with emergency management authorities, should determine the number of emergency levels required for each dam on a case-by-case basis.

- High flow
- Non-failure
- Potential failure
- Imminent failure

The EAP should describe how each emergency level applies to the particular dam. Information to assist the dam owner in determining the appropriate emergency level should be developed and included in the EAP. An example table describing emergency level for different incidents is included in Appendix D. The four emergency levels are discussed below.

High Flow. The High Flow emergency level indicates that flooding is occurring on the river system, but there is no apparent threat to the integrity of the dam. The High Flow emergency level is used by the dam owner to convey to outside agencies that downstream areas may be affected by the dam's release. Although the amount of flooding may be beyond the control of the dam owner, information on the timing and amount of release from the dam may be helpful to authorities in making decisions regarding warnings and evacuations.

Notifications should be predetermined based on correlations between releases and the timing of impacts to downstream areas. High Flow emergency level notifications are typically made to local jurisdictions that would be affected, the NWS, downstream dam owners, and other agencies, as necessary. For smaller dams that have no downstream impact from releases, this category may not be necessary. If the High Flow emergency level is used, dam owners should

consider developing a table that correlates gate openings and/or reservoir levels to outflows, expected downstream impacts, and agencies that will be contacted. An example table is provided in Appendix E.

Non-Failure. The Non-Failure emergency level is appropriate for an event at a dam that will not, by itself, lead to a failure, but requires investigation and notification of internal and/or external personnel. Examples are (1) new seepage or leakage on the downstream side of the dam, (2) presence of unauthorized personnel at the dam, and (3) malfunction of a gate.



Earthen dam seepage

Some incidents, such as new seepage, may only require an internal response from the dam owner. Others, such as a gate malfunction, may lead to unexpected high releases that could pose a hazard to the downstream public and would require the notification of outside agencies.

Potential Failure. The Potential Failure emergency level indicates that conditions are developing at the dam that could lead to a dam failure. Examples are (1) rising reservoir levels that are approaching the top of the non-overflow section of the dam, (2) transverse cracking of an embankment, and (3) a verified bomb threat. Potential Failure should convey that time is available for analyses, decisions, and actions before the dam could fail. A failure may occur, but predetermined response actions may moderate or alleviate failure.

Imminent Failure. The Imminent Failure emergency level indicates that time has run out, and the dam has failed, is failing, or is about to fail. Imminent Failure typically involves a continuing and progressive loss of material from the dam. It is not usually possible to determine how long a complete breach of a dam will take. Therefore, once a decision is made that there is no time to prevent failure, the Imminent Failure warning



Failure of Teton Dam (Idaho) from seepage (1976)

must be issued. For purposes of evacuation, emergency management authorities may assume the worst-case condition that failure has already occurred.

Step 2: Notification and Communication

After the emergency level at the dam has been determined, notifications are made in accordance with the EAP's Notification Flowchart(s). Details on the use of the Notification Flowchart and any additional contact information should be provided in the EAP.

When developing notification and communication procedures, dam owners should coordinate closely with emergency management authorities. All parties must understand that the formal declaration of public emergency by emergency management authorities can be a very difficult decision. During this step, the dam owner should provide any information that will assist in that decision. An early decision and declaration are critical to maximizing available response time.

When performing notification and communication activities, it is important that people speak in clear, nontechnical terms to ensure that those being notified understand what is happening at the dam, what the current emergency level is, and which actions to take. To assist in this step, the EAP may include checklists and/or prescribed messages to help the caller adequately describe the emergency situation to emergency management authorities. Different messages can be developed for each emergency level. Examples of a notification checklist and prescribed messages are included in Appendix F.

After initial notification, the dam owner should make periodic status reports to the affected emergency authorities and other stakeholders in accordance with the Notification Flowcharts and associated procedures. If it appears that the situation is continuing to deteriorate despite actions being taken to moderate or alleviate failure, local authorities may decide to change their course of action. Depending on the location of downstream residents and the estimated time required to warn them, the evacuating agencies may consider early evacuation or continued warnings until the emergency has passed.

Step 3: Emergency Actions

After the initial notifications have been made, the dam owner will act to save the dam and minimize impacts to life, property, and the environment. During this step, there is a continuous process of taking actions, assessing the status of the situation, and keeping others informed through communication channels established during the initial notifications. The EAP may go through multiple emergency levels during Steps 2 and 3 as the situation improves or deteriorates. The dam owner should develop tables that include specific actions for minimizing impacts of dam safety incidents. An example table is provided in Appendix G. Additional information related to response actions may also be provided in the dam operating manuals and instructions.

During an incident, safety and security measures should be implemented to secure the affected operational areas at the dam to protect operations personnel and the public, and permit an effective performance of emergency response actions.

Step 4: Termination and Follow-up

The EAP should explain the expected termination and follow-up procedures for dam safety incidents and emergencies. This step should explain the process to follow and the criteria for determining that the incident at the dam has been resolved. A Dam Emergency Termination Log may be developed and used to document conditions and decisions. An example log form is provided in Appendix I. Generally, the dam owner, or the dam owner's dam safety expert, is responsible for notifying the authorities that the condition of the dam has been stabilized. Government officials are responsible for declaring an end to the public emergency response.

Following the termination of an incident, the dam owner, in coordination with emergency management authorities, should conduct an evaluation that includes all affected participants. At a minimum, the following should be discussed and evaluated in an after-action review:

- Events or conditions leading up to, during, and following the incident
- Significant actions taken by each participant and improvements for future emergencies
- All strengths and deficiencies found in the incident management process, materials, equipment, staffing levels, and leadership
- Corrective actions identified and a planned course of action to implement recommendations

The results of the after-action review should be documented in an After Action Report (AAR) and used as a basis for revising the EAP. The dam owner should participate in the after-action review and the development of the AAR.

f. General Responsibilities

A determination of responsibility for EAP-related tasks must be made during the development of the plan. Dam owners are responsible for developing and maintaining the EAP. Dam owners in coordination with emergency management authorities are responsible for implementing the EAP. Emergency management authorities with statutory obligations are responsible for warning and evacuation within affected areas. All entities involved with EAP implementation should document incident-related events. Appendix I includes an example Emergency Incident Log.

The EAP must clearly specify the responsibilities of all involved entities to ensure that effective and timely action is taken if an emergency at the dam occurs. The EAP must be site-specific because conditions at the dam and upstream and downstream of the dam are unique to every dam. Some responsibilities to be considered are discussed below. An example summary of EAP responsibilities is provided in Appendix B, Table B-1.

Dam Owner Responsibilities

The duties of the dam owner should be clearly described. In general, the dam owner is responsible for detecting and evaluating dam safety incidents, classifying the incident, notifying emergency management authorities, and taking appropriate response actions.

The dam operator's duties should be described in the EAP, and operators should be trained on the importance and use of the plan. Examples of duties may include opening spillway gates per a required sequence and opening or closing water intakes, as appropriate. Instructions for the operation of the project during the anticipated emergency should be provided.

The chain of command in the dam owner's organization should be clearly described. Officials and alternates that must be notified should be identified and priority of notification determined. Notification of supervisory personnel is recommended if time permits. Advice may be needed concerning predetermined remedial action to delay, moderate, or alleviate the severity of the emergency condition. Responsibilities should be coordinated with appropriate levels of management to ensure full awareness of organizational capabilities and responsibilities. An example summary table identifying actions that each member of the dam owner's organization will take during the incident or emergency is provided in Appendix B, Table B-2.

Notification and Communication Responsibilities

The individuals authorized to notify emergency management authorities should be determined and clearly identified in the EAP. If time allows, onsite personnel may be able to seek internal advice and assistance. However, under an Imminent Failure condition, the responsibility and authority for notification may have to be delegated to the dam operator or a local official. When developing the EAP, the dam owner and emergency management authorities should discuss and determine the most efficient notification protocol to follow.

Throughout the United States, the NWS and/or other agencies have the primary responsibility for issuing flood warnings. It is highly recommended that the Notification Flowchart include the agency with this responsibility so that its facilities can enhance warnings being issued.



Emergency Operations Center

Once notified of an incident at the dam, local emergency management authorities may activate an Emergency Operations Center (EOC) to serve as a central coordination center for emergency response, warning, and evacuation activities. A representative of the dam owner should go to the EOC to help agency personnel understand the project-specific information and inundation maps.

Interaction with the media should be implemented through the local or State emergency management authority. These agencies should have a Public Information Officer (PIO) and/or a Joint Information Center for disseminating information and handling inquiries. It is highly recommended that the dam owner and the appropriate incident or emergency management authority work in partnership to accomplish this task.

Proper coordination and communication among onsite technical personnel at the dam, PIOs, and emergency personnel at the EOC are of critical importance to the successful implementation of the EAP. These activities should be thoroughly tested during comprehensive EAP exercises and modified as necessary.

Evacuation Responsibilities

Warning and evacuation planning and implementation are responsibilities of local emergency management authorities with the legal authority to perform these actions. Under the EAP, the dam owner is responsible for notifying the appropriate emergency management authority when an incident is anticipated, is imminent, or has occurred. Warning and evacuation protocols are key elements in an EAP exercise but are not typically included in the EAP. The EAP should, however, clearly describe the notification, warning, and evacuation responsibilities of the dam owner and the local emergency management authority.

Dam owners should not assume or usurp the responsibility of government entities for evacuation of people. However, there may be situations in which routine notification and evacuation will not be sufficient, as in the case of a residence located immediately downstream of a dam or a campground that would be inundated within minutes of a dam failure. In some cases, dam owners may arrange to notify the residence or campground directly. Such procedures should be coordinated with the appropriate authorities before an emergency situation develops.

Monitoring, Security, Termination, and Follow-Up Responsibilities

A person should be designated as an onsite monitor from the beginning of a dam safety incident until the emergency has been terminated. This person should provide status updates to the dam owner so the owner can keep all those involved with the implementation of the EAP informed of developing conditions.

Provisions for security measures during the emergency should be specified in the EAP. For additional information on security measures, see *Dams Sector Security Awareness Guide: A Guide for Owners and Operators* (DHS, 2007), available at www.dhs.gov/xlibrary/assets/ip_dams_sector_security_awareness_guide.pdf.

Termination of a dam safety emergency is usually twofold. The entity that activates the EAP is usually responsible for determining when the dam safety situation has stabilized. This is typically the dam owner in consultation with engineers and dam safety experts but may include other State and Federal regulatory entities. The applicable emergency management authorities, on the other hand, are responsible for termination of the emergency response activities, including termination

of an evacuation. Both the dam owner and the emergency response authorities should coordinate closely while making decisions to terminate both the dam safety event and response efforts.

Recovery activities will continue on different levels for all involved in the dam safety incident after the emergency has been terminated. Although not typically addressed in a dam EAP, recovery activities should be considered by all dam owners and particularly for those dams that can affect a critical public utility such as water supply or electricity.

The dam owner should coordinate a follow-up evaluation after any emergency. All participants should be involved in this evaluation and should keep logs and records during the incident. An example Emergency Incident Log and Emergency Termination Log are presented in Appendix I. The results of the follow-up evaluation should be documented in a written report (After Action Report) and used to improve future response actions.

EAP Coordinator Responsibilities

The dam owner should specify an EAP Coordinator who will be responsible for overall EAP-related activities, including but not limited to preparing revisions to the EAP, establishing training seminars, and coordinating EAP exercises. This person should be the EAP contact for questions about the plan.

g. Preparedness

Preparedness, as it relates to an EAP for a dam, typically consists of activities and actions taken before the development of an incident. Preparedness activities attempt to facilitate response to an incident as well as prevent, moderate, or alleviate the effects of the incident. This section of the EAP should describe preparedness actions already completed, as well as established preplanned actions that can be taken after the development of emergency conditions.

Examples of preparedness actions include conducting regular inspections or surveillance, installing monitoring equipment, installing warning sirens, developing emergency operating instructions, and planning for equipment, labor, and materials to be used in emergency situations.

At a minimum, the EAP should address the following categories related to preparedness:

- Surveillance and monitoring
- Evaluation of detection and response timing
- Access to the site
- Response during periods of darkness
- Response during weekends and holidays
- Response during periods of adverse weather
- Alternative sources of power

- Emergency supplies and information
- Training and exercising
- Alternative systems of communication
- Public awareness and communication

The following sections discuss these categories.

Surveillance and Monitoring

The EAP should contain provisions for surveillance and monitoring at the dam. Prompt detection and evaluation of information from instrumentation and physical monitoring is critical to the effectiveness of the EAP and timely emergency response. Consideration should be given to times when the dam is attended and unattended.

When a dam is not continuously attended and an incident could endanger life or cause significant property damage, it is imperative that instrumentation be installed and/or procedures developed to monitor conditions at the facility. To promptly identify and notify emergency management authorities of emergency conditions, a dam owner should be able to detect, confirm, and evaluate developing conditions. Monitoring systems must be able to deliver clear, concise, and reliable information so that emergency authorities with warning and evacuation responsibilities may be promptly alerted.



Seepage weir and collection box

While the EAP is being activated, personnel should visit the site to verify and continue to monitor conditions.

For an unattended dam, remote surveillance systems that include instrumentation for continuous monitoring of headwater and tailwater levels should be considered. If the dam owner has an operations center that is attended 24 hours a day, these systems should include monitoring for water level rate of change and alarms when prescribed limits or levels are exceeded. Monitoring system design must be site-specific and account for changes in headwater and tailwater that may occur during normal dam operations, floods, and maintenance activities.

Tailwater monitoring is generally more sensitive to a dam breach than headwater monitoring. Changes in tailwater will alert operators more quickly to site conditions and help determine whether the EAP should be implemented. If continuous readings of both the headwater and

tailwater are available, the operator can obtain concurrent readings at any time and verify alarm conditions.

If automated monitoring systems are used, provisions should be made for indicating power interruptions and loss of communication with the monitoring instrumentation. When a dam operator lives close to a project, consideration may be given to installing an alarm at the operator's home. When power to, or communication with, the site is interrupted, the dam should be manned until conditions return to normal. Operation of the alarms should be checked periodically. Proper functioning of alarms should be confirmed by testing. For instance, annual testing of the EAP may be initiated by artificially tripping one of the alarms.

Reaction time must be minimized when inhabited structures are located immediately downstream of the dam. When these conditions exist, special procedures may need to be included in the EAP to notify the occupants involved. Local emergency management authorities should be fully involved in the development of these special procedures.

Procedures should be described for providing continuous surveillance for periods of actual or forecasted high flows. It may be necessary to send an observer to the dam during these periods and not rely on the instrumentation alone. It is very important that an observer be at the dam when flood conditions or signs of serious structural distress have been identified, provided that it is safe to do so.

If remote surveillance at the dam is not applicable, reasons to support that decision should be provided in this section of the EAP.

Backup systems and procedures should be developed to verify that instrumentation readings are correct. Camera systems that can be accessed from the command center or over the Internet can allow for quick verification of water level alarms and other dam safety conditions.

Evaluation of Detection and Response Timing

Total EAP implementation time from the initiation of an actual incident to determination of an emergency situation and notification of appropriate entities involved with implementation should be evaluated and understood. The impact of the timing should be considered when developing preparedness actions. Timely implementation of the EAP and coordination and communication with emergency management authorities are crucial elements in the effectiveness of the emergency response effort.

Access to the Site

The description of access should focus on primary and secondary routes for reaching the site using various access methods (e.g., foot, boat, helicopter, snowmobile). The expected response time should also be discussed. If the main road to the dam crosses the downstream channel and could be impassable due to flood waters, this situation should be identified and alternate access options described.



Flooded road

Response during Periods of Darkness

Response to potential or actual emergency conditions during periods of darkness should be clearly addressed in the EAP and include any special instructions for the dam operator and/or emergency management authorities. Response times, if different from daylight, should also be included.

Actions to be taken to illuminate the abutments, spillways, operating decks, non-overflow sections, or other areas where failures could occur should be described. Other actions that may facilitate the operation of gates or other emergency equipment should be described if they are different during periods of darkness.

Any special procedures during a power failure should be provided, including manual operation of electrically powered equipment and any additional notification requirements.

Response during Weekends and Holidays

Response during weekends or holidays should be clearly addressed in the EAP and include any special instructions for the dam operator and/or emergency management authorities. Response times, if different from non-holiday or weekdays, should also be included. The availability of the dam operator should be considered, and any special procedures for contacting or notifying personnel addressed.

Response during Adverse Weather

Response under adverse weather conditions should be included and any specific actions to be taken described in detail. Actions should be based on whether the dam is attended or unattended. Methods of access to the site (e.g., foot, boat, snowmobile) should be described. The expected response time should be discussed in detail. Any other special instructions for the dam operators or emergency management authorities should be described.

Alternative Sources of Power

Alternative sources of power for spillway gate operation or other emergency needs should be identified in the EAP. The plan should list the location of each alternate power source, its mode of operation and, if portable, a means of transportation with routes to be followed.

Emergency Supplies and Information

Planning and organizational measures that can help the dam owner and emergency management authorities manage an emergency situation more safely and effectively include stockpiling materials and equipment for emergency use and coordinating information between organizations.

The availability of local resources should be predetermined through discussions with local emergency management authorities and additional resource needs should be identified. The EAP should include the name and contact information (including backups) for suppliers, additional personnel, contractors, consultants, and any other entities who may be needed to assist the dam owner or emergency management authorities in responding to a dam emergency.

Stockpiling Materials and Equipment

Where applicable, the following should be documented:

- Materials needed for emergency repair, including source; materials should be as close as possible to the dam site
- Equipment needed for emergency response or repair, its location, and who will operate it
- Local contractors, vendors, and suppliers for dam-related equipment and supplies, including contact information and maps or directions to their locations
- Justification of decision not to stockpile materials and equipment if stocking is not warranted

Coordination of Information

Where applicable, the following should be described:

- The need for coordination of information on flows based on weather, runoff forecasts, dam failure, and other emergency conditions, including how coordination is achieved and the chain of communication, including names and contact information for responsible parties. Coordination with the NWS or other appropriate agency is recommended to monitor storms, river stages, and flood waves resulting from a dam break. The NWS or other appropriate agency may also be able to supplement the warnings being issued by using its own communication system. If coordination of information on flows is not applicable, this decision should be documented in the EAP.

- Actions to be taken to lower the reservoir water surface elevation, if applicable, including when and how this action should be taken. If not applicable, this should be documented in the EAP.
- Actions to be taken to reduce inflow to the reservoir from upstream dams or control structures. The EAP should provide instructions for contacting operators of these structures and how these actions should be taken. If such actions do not apply, this should be documented in the EAP.
- Actions to be taken to reduce downstream flows, such as increasing or decreasing outflows from downstream dams or control structures on the waterway on which the dam is located or its tributaries. The EAP should provide instructions for contacting operators of these structures and how these actions should be taken. If such actions do not apply, this should be documented in the EAP.

Training and Exercise

Results of training and exercise programs are critical components in evaluating the effectiveness of an EAP. Training and exercise plans should be designed and developed by those entities with responsibilities identified in the EAP. Since many emergency management authorities follow the FEMA Homeland Security Exercise and Evaluation Program (HSEEP) framework, HSEEP should be considered by the dam owner and other entities involved with the EAP when developing training and exercise activities. More information on the HSEEP can be found at hseep.dhs.gov.

Training. The people involved in the implementation of the EAP should be receive training to ensure that they are thoroughly familiar with all elements of the plan, the available equipment, and their responsibilities and duties under the plan.

Technically qualified personnel should be trained in the incident management process, including detection, evaluation, notification, and appropriate response actions during all emergency level determinations. A sufficient number of people should be trained to ensure adequate coverage at all times. A brief description of the training performed at the dam and how often it is performed should be included in the EAP.

Local emergency management authorities may want to consider developing evacuation and shelter-in-place training materials for people who would be affected by a dam failure in their jurisdiction. This is particularly important when a dam is categorized as unsafe or the population immediately downstream of a dam would be inundated within a short time frame.

Exercise. If the EAP action items and procedures are not exercised periodically, those involved in its implementation may lose familiarity with their roles and responsibilities. A proposed exercise schedule and plans for an EAP exercise program should be included in the EAP. Plans for conducting an evaluation of the exercise and for updating the EAP based on the outcome of the evaluation should be considered. See Appendix H for a discussion of the types of EAP exercises, frequency of exercises, and procedures for evaluation.



Tabletop exercise

Alternative Systems of Communication

The availability of alternative communications systems at the dam site should be identified in the EAP. These may include, but are not limited to, emergency sirens, cellular phones, direct connect, e-mail, intranet, radios, social media, and couriers. Operating procedures and special instructions for the use of these systems should be described. Consideration should be given to the target audience involved and the best means for communicating with them.

Public Awareness and Communication

Dams that are immediately upstream of residences, recreation areas, and campgrounds pose unique challenges. It may be necessary for the dam owner to assist emergency management authorities in developing public awareness measures. These measures typically explain the proximity of the dam, how people will be informed of an emergency, and the actions people should take during an emergency. The EAP should include a brief description of any public awareness measures that are performed. Emergency management authorities may consider the use of social media for both primary and alternate systems of communication with the public.

3. Inundation Maps

The primary purpose of an inundation map is to show the areas that would be flooded and travel times for wave front and flood peaks at critical locations if a dam failure occurs or there are operational releases during flooding conditions. Inundation maps are a necessary component of the EAP and are used both by the dam owner and emergency management authorities to facilitate timely notification and evacuation of areas potentially affected by a dam failure or flood condition. See Figure 1.

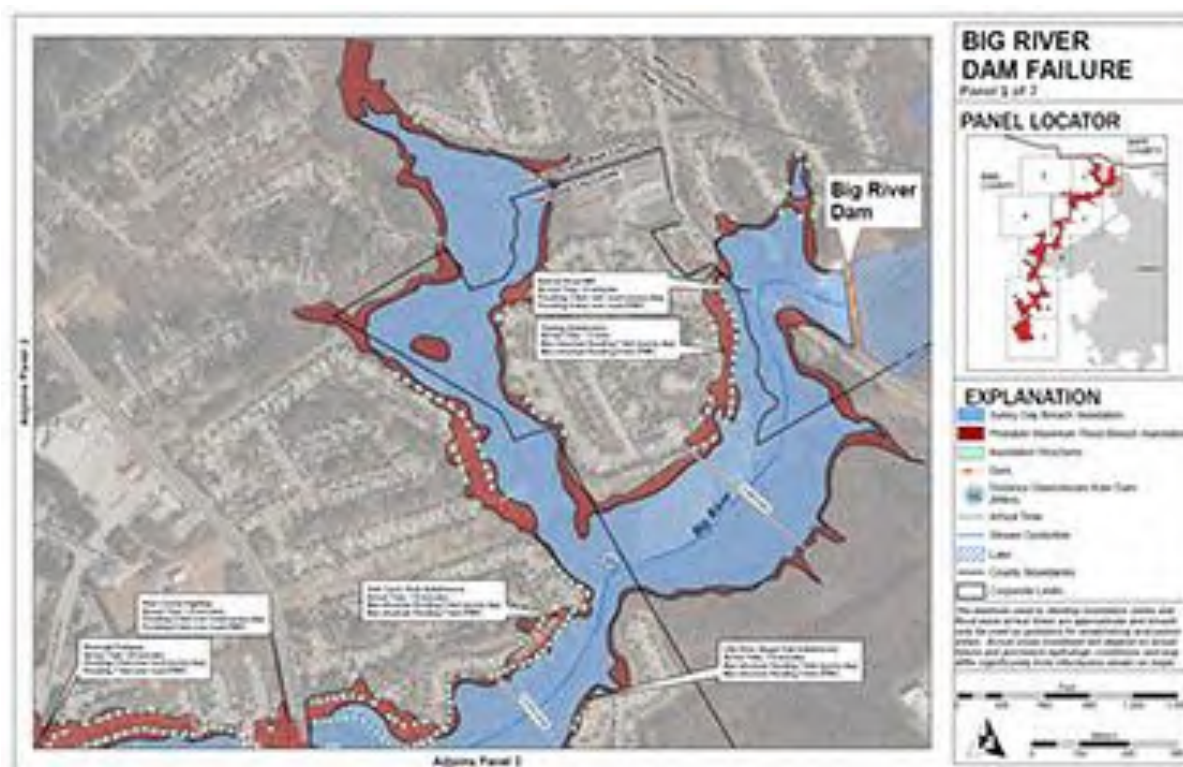


Figure 1. Inundation Map

Inundation maps should be developed by the dam owner in coordination with the appropriate emergency management authorities. The purpose of this coordination is to ensure that (1) the authorities understand how to interpret the maps and (2) the maps contain sufficient and current information for the authorities to warn and evacuate people at risk from a dam failure.

a. Determining Downstream Impacts

Several factors have to be evaluated when dam failure inundation zones are being determined. The type of dam and the mechanisms that could lead to failures require careful consideration if a realistic breach scenario is to be developed. Size and shape of the breach, time of breach formation, hydraulic head, and storage in the reservoir are all inputs into the development of a dam failure hydrograph. The best available topographic data should be used for developing accurate volume and routing estimates. There are several methods and computer models available for developing the dam failure hydrograph and routing dam break flows downstream. Models that use unsteady flow and dynamic routing method are preferable.

Different inflow conditions at the time of the dam failure should be considered to ensure that the EAP includes all communities that need to be notified. A “fair weather” or “sunny day” dam failure, in which the reservoir is at normal full pool elevation and normal stream flow is prevailing, is generally considered to have the most potential for loss of human life due to the element of surprise. Failure of a dam during flood flow conditions, however, will result in

downstream inundation at higher elevations and will include additional affected populations. A failure at the dam's Inflow Design Flood (IDF) is considered to show the upper limit of inundation.

A sensitivity analysis (i.e., varying the breach parameters such as breach width and time to failure for the various flood inflow conditions) is recommended in order to fully investigate the effect of a failure on downstream areas. A sensitivity analysis allows the reviewer to identify the effect of various failure scenarios in order to select the most appropriate failure mode for developing the EAP.

If the assumed failure of a dam would cause the failure of any downstream dams, the analysis should consider the domino effect in routing the flood wave downstream. For example, if a downstream dam has an earthen embankment that would be significantly overtopped due to the upstream dam failure, then it may be necessary that the inundation zone reflect the additional flooding from failure of the downstream dam. Many factors should be considered for these cases, such as the expected performance of the downstream dams during high flows, the lag time between dams, and possible operation actions at downstream dams (e.g., drawdowns) that could alleviate the flood wave. Coordination of such studies with other downstream dam owners should be undertaken when feasible. The flood wave should be routed to a point where it no longer presents a hazard to downstream life or property.

b. Preparing Inundation Maps

Inundation maps should clearly show inundation zones, cross section information, dams, streets, buildings, railroads, bridges, campgrounds, and any other significant features. At the request of emergency management authorities, additional features, such as highlighted evacuation routes and emergency shelters may be included on the maps. All features should be shown using local names or terms. Printed inundation maps should be at a scale that is sufficient to clearly show the downstream inhabited areas within the inundation zones.

To assist emergency management authorities with potential evacuations, the maps should show areas inundated from a dam failure during "fair weather" and IDF conditions. The maps also typically show normal water levels. If inundated areas for the "fair weather" breach and the IDF breach are essentially the same or too close to be shown separately on the inundation maps, a single inundation area for the two breach conditions may be shown.

The lines delineating the inundated area should be drawn in such thickness or form (solid line, dashed line, dotted line) as to readily identify the inundation limits as the main features of the map but not bold enough to block houses, roads or other features which are inundated by the flood waters. The area between the inundation lines representing the water level may be shaded or colored to distinguish the area of inundation. Care should be taken to select shading or colors that will not block important features on the map. Additionally, critical features or inundated structures can be highlighted to ensure visibility.

When plotting inundation limits between cross sections used for analysis, the lines should reasonably reflect the change in water levels with consideration given to topographic patterns and both natural and manmade features.

When inundation lines enter the area of an existing lake or reservoir, they should be drawn to represent an increase in the water level of the lake or reservoir. If the increased water level overtops a dam, the appropriate inundation lines should continue downstream of the dam to represent the expected flooding.

The maps should include cross section information for selected areas downstream of the dam. The following information should be included for the “fair weather” breach and IDF breach scenarios:

- Distance of cross section downstream from the dam
- Travel times (in hours and minutes) of the leading edge and peak of the dam break flood waves starting from when the dam fails
- Expected peak water surface elevations
- Incremental rises in water levels
- Peak discharges
- Estimated duration of inundation

The dam owner should try to prepare maps using terms understood by all emergency responders. For example, a local responder may prefer that the maps show the expected height of water over a road instead of peak water elevation. However, the NWS may need the incremental rise and water level to issue flood warnings.

c. Additional Information

Care should be taken not to include too much technical information on the inundation maps. Excess information will hamper the first responder’s ability to quickly glean critical information from the map. A “Notes” sheet can be included to provide additional information, and detailed information supporting the development of the maps can be provided in an appendix for reference.

The following information should be included with the inundation maps, as applicable:

- A map index if inundation maps are shown on several sheets
- The antecedent flow conditions the maps are based on and any other pertinent dam breach information
- Water surface profiles showing the elevation prior to failure, the peak water surface elevation after failure, and highlighted locations of critical structures

- Written description of the areas affected by the dam break to clarify unusual conditions and the specific area threatened, including the extent and depth of the expected flooding, relative to known landmarks and historical flood heights
- Justification for providing only one inundation zone on the maps instead of both the “fair weather” and IDF conditions, if applicable
- Accuracy and limitation of the information supplied on the inundation maps and how to use the maps. A note should advise that because of the methods, procedures, and assumptions used to develop the flooded areas, the limits of flooding shown and flood wave travel times are approximate and should be used only as a guideline for establishing evacuation zones. Areas that are inundated depend on actual failure or flooding conditions and may differ from the areas shown on the maps.

4. Part II. Appendices

Appendices follow the main body of the EAP and contain information that supports and supplements the material used in the development and maintenance of the EAP.

Some of the topics that should, at a minimum, be contained in the appendices are:

- Investigation and analyses of dambreak floods
- Plans for updating and distributing the EAP
- Plans for posting the Notification Flowcharts
- Forms and Log Sheets
- Site-specific concerns

Each topic is discussed below.

a. Investigations and Analyses of Dam Break Floods

Although inundation maps are usually provided in the main body of the EAP, details regarding the development of the maps should be in an appendix. See Chapter II, Section B.3, for a discussion of the development of inundation maps. The following types of detailed information may be included in an appendix:

- Type of dam
- Assumed size, shape, and location of breach
- Assumed time of breach formation
- Assumed water surface elevation at failure
- Storage-reservoir curve
- Method/computer model used to determine downstream impacts

- Source of topographic data used
- Source of the base map
- Inflow hydrographs for fair weather and flood conditions
- Discussion of any sensitivity analyses performed and the reasons for the selected values
- Reason for or against including a domino failure of downstream dams
- Table showing output results at cross sections for pre- and post-failure conditions

b. Plans for Reviewing, Revising, and Distributing the EAP

As described in Chapter I, Section F, once developed, the EAP must be continually reviewed and periodically revised and redistributed. Plans for these activities should be documented in an appendix. In addition to a narrative description of this process, distribution lists and a formal record of reviews and revisions should be included. Example forms for reviewing, revising and distributing the EAP are provided in Appendix I.

c. Notification Flowchart

An up-to-date copy of the Notification Flowchart should be posted in prominent places at the dam site and operations center. Posting at appropriate emergency operations centers is also recommended. Maintaining a list of all posting locations in the EAP will ensure that new flowcharts are posted when updates are performed.

d. Blank Forms and Log Sheets

For easy access and use during an incident, blank forms and log sheets may be placed in an appendix. Forms may include a Record of EAP Reviews and Updates, record of Plan Holders, Emergency Incident Log, and Emergency Termination Log.

e. Site-Specific Concerns

Each dam and upstream and downstream areas are unique. As a result, each EAP is unique. Appendices can provide a discussion of site-specific issues that provide valuable information affecting the EAP and its implementation. References to where appropriate structural drawings and flood data are maintained may be helpful. Quick access to this information may be crucial during an emergency event.

III. GLOSSARY

Breach: An opening through the dam resulting in partial or total failure of the dam.

Consequences: Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of dam. Includes effects of landslides upstream of the dam on property located around the reservoir.

Dam failure: Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water. There are lesser degrees of failure, but any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. Lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amendable to corrective action.

Dam owner: Entity that owns the dam and associated facilities. The dam owner also includes the dam operator and operating organization.

Emergency Action Plan (EAP): Formal document that identifies potential emergency conditions at a dam and specifies preplanned actions to be followed to minimize property damage and loss of life. The EAP describes actions the dam owner will take to moderate or alleviate a problem at the dam, as well as actions the dam owner, in coordination with emergency management authorities, will take to respond to incidents or emergencies related to the dam.

EAP exercise: Activity designed to promote prevention, preparedness, and response to incidents and emergencies, and may also be extended to include recovery operations. The exercise also demonstrates the EAP's effectiveness in an actual situation and demonstrates the readiness levels of key personnel. Periodic exercises result in an improved EAP because lessons learned are incorporated into the updated EAP document. Exercises consist of testing and performing the duties, tasks, or operations identified and defined within the EAP through a simulated event.

Emergency: Any incident, whether natural or manmade, that requires responsive action to protect life or property.

Emergency alert system: A federally established network of commercial radio stations that voluntarily provide official emergency instructions or directions to the public during an emergency.

Emergency management authority: State, local, Tribal, or Territorial agency responsible for emergency operations, planning, mitigation, preparedness, response, and recovery for all hazards. Names of emergency management authorities vary (e.g., Division of Emergency Management, Comprehensive Emergency Management, Disaster Emergency Services, Emergency and Disaster Services).

Emergency Operations Center: The location or facility where responsible officials gather during an emergency to direct and coordinate emergency operations, to communicate with other jurisdictions and with field emergency forces, and to formulate protective action decisions and recommendations during an emergency.

Flood hydrograph: Graph showing the discharge, height, or other characteristic of a flood with respect to time for a given point on a stream.

Flood routing: Process of determining progressively, over time, the amplitude of a flood wave as it moves past a dam or downstream to successive points along a river or stream.

Hazard potential: Situation that creates the potential for adverse consequences, such as loss of life, property damage, or other adverse impact. Impacts may be for a defined area downstream of a dam from floodwaters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. They may also be for an area upstream of the dam from the effects of backwater flooding or the effects of landslides around the reservoir perimeter.

Headwater: Water immediately upstream from a dam. The water surface elevation varies due to fluctuations in inflow and the amount of water passed through the dam.

Incident: An incident in terms of dam operation includes an impending or actual sudden release of water caused by an accident to, or failure of, a dam or other water retaining structure, or the result of an impending flood condition when the dam is not in danger of failure, or any condition that may affect the safe operation of the dam. The release of water may or may not endanger human life, downstream property and structures, or facility operations.

Inflow Design Flood (IDF): Flow used in the design of a dam and its appurtenant works, particularly for sizing the spillway and outlet works, and for determining the maximum height of the dam, freeboard, and temporary storage requirements. The IDF is typically the flow above which the incremental increase in water surface elevation due to failure of a dam is no longer considered to present an unacceptable threat to downstream life or property. The upper limit of an IDF is the Probable Maximum Flood.

Inundation map: Map delineating areas that would be flooded as a result of a dam failure.

Inundation zone: Area downstream of the dam that would be inundated by the released water. This zone is typically demarcated by a boundary reflecting the vertical elevation of the peak flow of water for both a flood failure and “sunny day” failure situation.

Notification: To inform appropriate individuals about an emergency condition so they can take appropriate action.

Probable Maximum Flood (PMF): Flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that is reasonably possible in the drainage basin under study.

Tailwater: Water immediately downstream from a dam. The water surface elevation varies due to fluctuations in the outflow from the structures of a dam. Tailwater monitoring is an important consideration because a failure of a dam will cause a rapid rise in the level of the tailwater.

Appendix A

EAP Review Checklist

General Document Items

- ☐ Is the name of the dam and other relevant identifiers, such as NID, State, and Federal ID numbers, clearly labeled in large letters in the EAP?
- ☐ Is the document a controlled document (i.e., each distributed plan is individually numbered and contains a statement that the plan is not to be copied or distributed by anyone other than the dam owner)?
- ☐ Is there a table of contents?
- ☐ Are the roles and responsibilities of key emergency personnel clearly documented, preferably at the beginning of the document?
- ☐ Is there an up-to-date revision sheet provided near the beginning of the document?
- ☐ Are revision numbers and revision dates provided as footers on each page of the document?

Detection Items

- ☐ Are detection and/or early warning systems at the dam clearly described, including dam operators' observations, instrumentation systems, and observations by the general public?

Decision Making Items

- ☐ Are the emergency levels clearly described?
- ☐ Are there clear guidelines and decision criteria to help the dam owner determine the appropriate level for potential unusual and emergency conditions that could occur at the dam?

Notification and Communication Items

- ☐ Are primary and backup communication systems among the dam owner, local emergency responders, and other key stakeholders described in the document?
- ☐ Are the notification flowcharts complete and logical?
- ☐ Are phone numbers, after-hours phone numbers, and backup personnel listed on the notification flowcharts and emergency contact lists?
- ☐ Do the notification flowcharts include contacts to provide timely engineering support?
- ☐ Do the notification flowcharts include contacts for timely notification of local emergency management organizations for more serious emergency levels?
- ☐ Do the notification flowcharts minimize the number of calls that dam operators are required to make, so that they can focus on implementing preventative actions? (Optimally, one or two calls per entity is best with no more than four calls)

Pre-planned Action Items

- ☐ Are there descriptions of recommended preplanned actions for potential unusual and emergency conditions at the dam?
- ☐ Is there a list of locally available engineering, labor, materials, and equipment resources that can be referenced in an emergency?
- ☐ Has the contact information for the locally available resources been recently updated or verified?

Termination and Follow-up Items

- ☐ Is the person with the authority to terminate emergency operations identified?
- ☐ Are the procedures for terminating emergency operations clearly described?
- ☐ Is there guidance on follow-up responsibilities after the emergency is terminated?

Inundation Mapping

- ☐ Does the inundation map include a north arrow and bar scale?
- ☐ Are the inundation areas clearly delineated and labeled? This is especially important if there are “fair weather” failure and “PMF plus breach” inundation limits shown on the inundation maps.
- ☐ Does the inundation map include a qualification stating that the inundation limits for an actual dam failure may vary in some ways from what is shown on the inundation map?
- ☐ Are local roads, drainages, and other landmarks clearly labeled on the base map?
- ☐ Is the downstream limit of the inundation mapping logical (e.g., at a major reservoir, river, other water course)?
- ☐ Were channel cross sections taken at critical downstream locations, such as at major road crossings, schools, major population centers, etc.?
- ☐ Is the following flood inundation information provided at important downstream cross sections:
 - Peak flood stage
 - Floodwave arrival time
 - Time to peak discharge
 - Maximum water surface elevation
 - Peak discharge

Other Items

- ☐ Are clear procedures for testing and updating the document provided?
- ☐ Is the frequency of testing and updating the document clearly described?
- ☐ Is the person or position responsible for updating the document indicated along with current contact information for that person?
- ☐ Are the processes for training personnel in how to use the document and the frequency and responsibility for this training clearly described?
- ☐ Are key hydrologic/hydraulic data, such as spillway and outlet discharge curves and reservoir area capacity curves, provided?
- ☐ Does the document include a general location map that shows where the dam is located relative to other key local roads, drainages, and population centers?

Appendix B
EAP and Dam Owner Responsibilities

Appendix B: EAP and Dam Owner Responsibilities

In Table B-1, the dam and downstream areas are in both County X and County Y. Town Anywhere is only in County Y.

Table B-1: Summary of EAP Responsibilities

Entity	Responsibilities
Dam Owner / Operator	1. Verify and assess emergency conditions 2. Notify other participating emergency management agencies 3. Take corrective action at facility 4. Declare termination of emergency at facility 5. Update EAP on at least an annual basis 6. Respond to emergencies at the facility 7. Receive condition status reports from the dam operator
Town Anywhere (in County Y) Police, Fire and Rescue	1. Receive condition status reports from dam owner 2. Notify Public within Town Anywhere limits 3. Conduct evacuation from inundation areas within town limits, if required 4. Render assistance to County Y, as necessary 5. Render assistance to dam owner, as necessary
County X Police, Fire and Rescue, and Emergency Services	1. Receive condition status reports from dam owner 2. Notify public within County X 3. Conduct evacuation from inundation areas in County X, if required 4. Provide mutual aid to County Y, if requested and able
County Y Police, Fire and Rescue, and Emergency Services	1. Receive condition status reports from dam owner 2. Notify public within County Y 3. Conduct evacuation from inundation areas in County Y, if appropriate

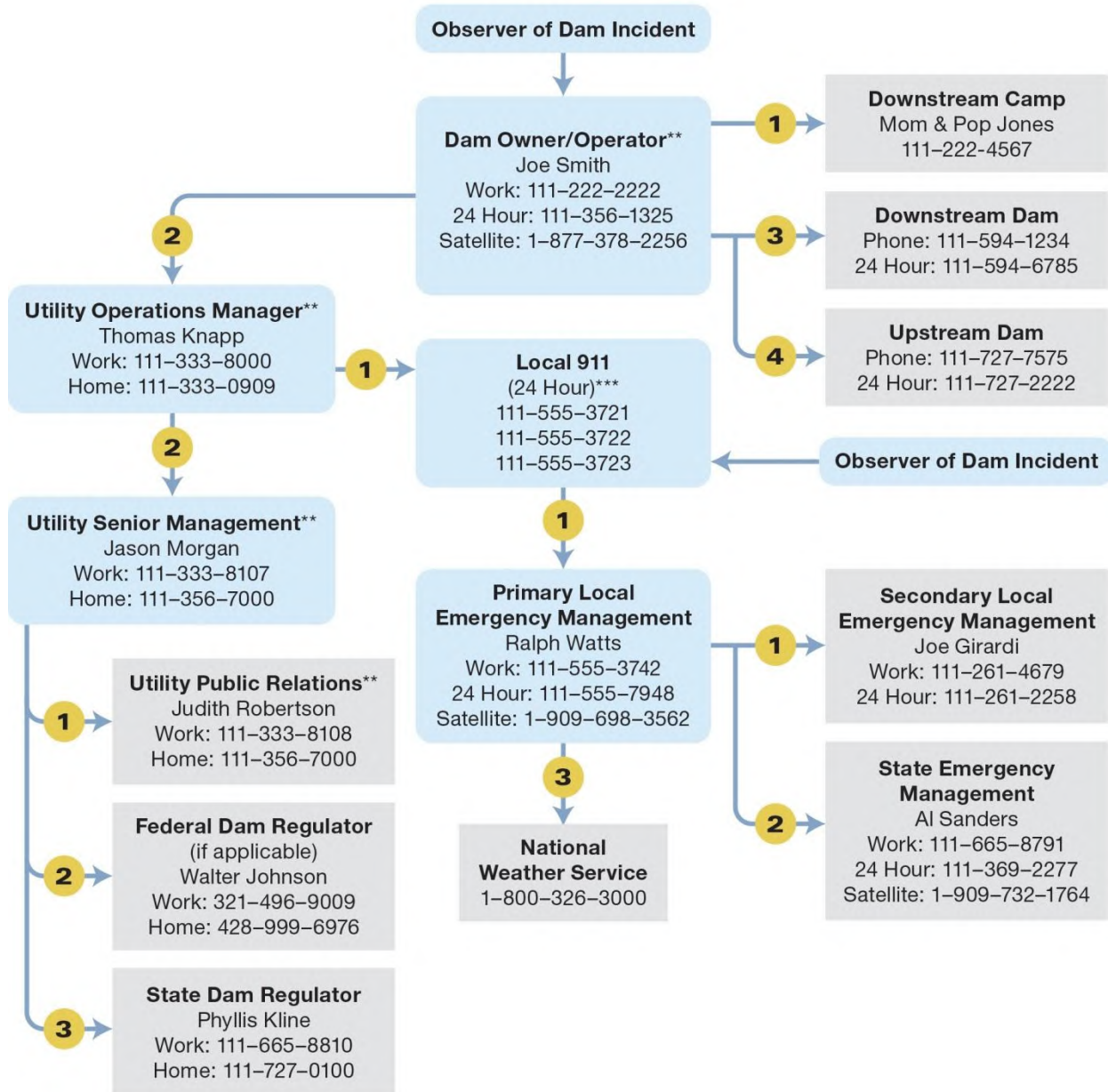
Appendix B: EAP and Dam Owner Responsibilities

Table B-2: Summary of the Dam Owner's Responsibilities

Entity	Responsibilities
24/7 Operations Command Center	1. Detect incident from alarms 2. Confirm incident by camera system 3. If no one is onsite, determine emergency level and dispatch operator to the site 4. Make calls on notification flow chart 5. Coordinate with Operator and Engineering on gate operations and emergency procedures 6. Coordinate with upstream and downstream dams on operations 7. Provide regular status reports to senior management
Onsite Dam Operator	1. Detect/confirm incident at dam 2. Determine emergency level 3. Make calls on Notification Flowchart 4. Coordinate with Command Center and Engineering on gate operations and emergency procedures 5. Implement gate operations and other emergency procedures 6. Provide regular status reports to senior management
Engineering Manager	1. Support onsite Operator and Operations Command Center on emergency level 2. Make calls on notification flow chart 3. Determine emergency operation and construction procedures 4. Coordinate with Operator and Command Center on gate operations and emergency procedures 5. Dispatch engineers and construction crews as necessary 6. Dispatch engineer as technical liaison to County Emergency Operations Center 7. Provide regular status reports to senior management
Senior Management	1. Make calls on Notification Flowchart 2. Initiate periodic status report conference calls with dam site, command center, engineering, and public relations 3. Provide regular status reports to County Emergency Operations Center 4. Coordinate with upper management 5. Coordinate with public relations staff at County and technical liaison at County Emergency Operations Center
Public Relations	1. Mobilize to County Offices 2. Participate in periodic status report conference calls with dam site, command center, engineering, and management 3. Provide input to staff on emergency communications 4. Represent utility to media

Appendix C
Example Notification Flowchart

Appendix C Example Notification Flowchart*



= call sequence

* Use this chart in coordination with Notification Contact Table for additional contact information.

** Utility personnel should refer to EAP for sample warning messages.

*** Call Dam Operator if 911 is notified by non-utility observer.

Figure C-1. Example Notification Flowchart

Appendix D
Sample Guidance Table for Determining Emergency Level

Appendix D: Sample Guidance Table for Determining Emergency Level

Table D-1 provides only examples.

Table D-1: Sample Guidance for Determining Emergency Level

Event	Situation	Emergency Level
Earth Spillway Flow	Reservoir water surface elevation at auxiliary spillway crest or spillway is flowing with no active erosion	Non-failure
	Spillway flowing with active gully erosion	Potential failure
	Spillway flow that could result in flood of people downstream if the reservoir level continues to rise	Potential failure
	Spillway flowing with an advancing headcut that is threatening the control section	Imminent failure
Embankment Overtopping	Reservoir level is XX feet/inches below the top of the dam	Potential failure
	Water from the reservoir is flowing over the top of the dam	Imminent failure
Seepage	New seepage areas in or near dam	Non-failure
	New seepage areas with cloudy discharge or increasing flow rate	Potential failure
	Seepage with discharge greater than XX gallons per minute	Imminent failure
Sinkholes	Observation of new sinkhole in reservoir area or on embankment	Potential failure
	Rapidly enlarging sinkhole	Imminent failure
Embankment Cracking	New cracks in the embankment greater than XX inches wide without seepage	Non-failure
	Cracks in the embankment with seepage	Potential failure
Embankment Movement	Visual movement/slippage of the embankment slope	Non-failure
	Sudden or rapidly proceeding slides of the embankment slopes	Imminent failure
Instruments	Instrumentation readings beyond predetermined values	Non-failure
Earthquake	Measurable earthquake felt or reported on or within XX miles of the dam	Non-failure
	Earthquake resulted in visible damage to the dam or appurtenances	Potential failure
	Earthquake resulted in uncontrolled release of water from the dam	Imminent failure
Security Threat	Verified bomb threat that, if carried out, could result in damage to the dam	Potential failure
	Detonated bomb that has resulted in damage to the dam or appurtenances	Imminent failure
Sabotage/ Vandalism	Damage that could adversely impact the functioning of the dam	Non-failure
	Damage that has resulted in seepage flow	Potential failure
	Damage that has resulted in uncontrolled water release	Imminent failure

Appendix E
Example High Flow Notification Table

Appendix E: Example High Flow Notification Table

Table E-1 is an example that correlates outflows from a dam, expected impacts, and the organizations that will be notified. Actual organizations and order of notification should be coordinated with all emergency management authorities involved.

Table E-1: Example High Flow Notification Table

Number of Gates Open	Flow (cfs)	Downstream Impacts	Organizations to be Notified
1-4	<10,000	None	None
5	12,500	Minor riverbank flooding	Town Police, National Weather Service, Downstream Dam Owner
6	15,000	Minor flooding of local roads near river	Town Police, National Weather Service, Downstream Dam Owner
7	17,500	Significant flooding of local roads near river	Town Police, National Weather Service, Downstream Dam Owner
8	20,000	State Highway 92 bridge flooded, significant flooding of local roads and houses near river	Local Police, National Weather Service, Downstream Dam Owner, State Emergency Management Authority

cfs = cubic feet per second

Appendix F
Emergency Notification Information and Messages

Appendix F: Emergency Notification Information and Messages

Table F-1 is an example of the information a dam owner will provide to external organizations during emergencies:

Table F-1: Examples of Notification Information by Emergency Level

Level	Information to External Organizations
High Flow	1. Explain how much flow the dam is currently passing, and the timing and amount of projected flows. 2. If known, describe at what flows downstream areas get flooded. 3. State that the dam is <u>NOT</u> in danger of failing. 4. Indicate when you will give the next status report. 5. Indicate who can be called for any follow-up questions.
Non-failure	1. Explain what is happening at the dam. 2. Describe if the event could pose a hazard to downstream areas (e.g., gate failure). 3. State that the dam is <u>NOT</u> in danger of failing. 4. Indicate when you will give the next status report. 5. Indicate who can be called for any follow-up questions.
Potential Failure	1. Explain what is happening at the dam. 2. State you are determining this to be a <u>POTENTIAL FAILURE</u>. 3. Describe what actions are being taken to prevent the dam failure. 4. Provide an estimate of how long before the dam would be at risk of failing (e.g., during floods that could overtop the dam). 5. Refer to the inundation maps and explain what downstream areas are at risk from a dam failure. 6. Indicate when you will give the next status report. 7. Indicate who can be called for any follow-up questions.
Imminent Failure	1. Explain that the dam is failing, is about to fail, or has failed. 2. State you are determining this to be an <u>IMMINENT FAILURE</u>. 3. Refer to the inundation maps and explain what downstream areas are at risk from a dam failure and estimate when flows should reach critical downstream areas. 4. Indicate when you will give the next status report. 5. Indicate who can be called for any follow-up questions.

Appendix F: Emergency Notification Information and Messages

The source of the following prescribed notification messages is the **sample** Emergency Action Plan (EAP) for Rock Creek Watershed, Dam No. 23, developed by the U.S. Department of Agriculture, Natural Resources Conservation Service. The emergency levels and parts of the messages have been modified to conform to this guidance document.

Potential Failure

This is _____ [your name and position].

We have an emergency condition at Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City.

We have activated the Emergency Action Plan for this dam and are determining this to be a **Potential Failure** condition.

We are implementing predetermined actions to respond to a rapidly developing situation that could result in dam failure.

Please prepare to evacuate the area along low-lying portions of Rock Creek.

The dam could potentially fail as early as 11 am today.

Reference the evacuation map in your copy of the Emergency Action Plan.

We will advise you when the situation is resolved or if the situation gets worse.

I can be contacted at the following number: _____.

If you cannot reach me, please call the following alternative number: _____.

Imminent Failure

This is an emergency. This is _____ [your name and position].

Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City, is failing.

The downstream area must be evacuated immediately.

Repeat, Rock Creek Watershed, Dam No. 23, is failing; evacuate the area along low-lying portions of Rock Creek.

We have activated the Emergency Action Plan for this dam and are determining this to be an **Imminent Failure** condition.

Reference the evacuation map in your copy of the Emergency Action Plan.

I can be contacted at the following number _____.

If you cannot reach me, please call the following alternative number: _____.

The next status report will be provided in approximately 30 minutes.

Appendix F: Emergency Notification Information and Messages

The following prescribed message may be used as a guide for emergency management authorities to communicate the status of the emergency with the public:

- Attention: This is an emergency message from the Sheriff. Listen carefully. Your life may depend on immediate action.
- Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City is failing. Repeat. Rock Creek Watershed, Dam No. 23, located 2 miles south of Rock City is failing.
- If you are in or near this area, proceed immediately to high ground away from the valley. Do not travel on Highway 44 south of Rock City or return to your home to recover your possessions. You cannot outrun or drive away from the flood wave. Proceed immediately to high ground away from the valley.
- Repeat message.

Appendix G
Example Emergency Level – Potential Failure

Appendix G: Example Emergency Level – Potential Failure

Table G-1: Example Emergency Level – Potential Failure

Condition	Description of Condition	Action to be Taken
High Water Level / Large Spillway Release	Reservoir level reaches elevation XXX ft. and is rising at a rate of greater than one foot per hour.	1. Check for signs of erosion from spillway channel, particularly near wing walls.
		2. Assess cause of increased reservoir stage, especially during fair weather conditions.
		3. Perform additional tasks as directed by Dam Engineer.
		4. Make notifications if condition worsens such that downstream flooding is imminent.
Seepage	Localized new seepage or boil(s) observed along downstream face / toe of earthen embankment with muddy discharge and increasing but controllable discharge of water.	1. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos if camera is available. Document location on a site plan and in inspection report.
		2. Place a ring of sand bags with a weir at the top towards the natural drainage path to monitor flow rate. If boil becomes too large to sand bag, place a blanket filter over the area using non-woven filter fabric and pea gravel. Attempt to contain flow in such a manner (without performing any excavations) that flow rates can be measured. Stockpile gravel and sand fill for later use, if necessary.
		3. Inspect the dam and collect piezometer, water level and seepage flow data daily unless otherwise instructed by engineer. Record any changes of conditions. Carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement.
		4. Contact geotechnical engineer and provide all data collected.
		5. Maintain continuous monitoring of feature. Record measured flow rate and any changes of condition, including presence or absence of muddy discharge.
		6. Review information collected by field inspection and provide additional instructions / actions as required. Recommend remedial seepage and stability measures.
		7. Make notifications if condition worsens such that failure is imminent.
Sabotage and Miscellaneous Other Issues	Criminal action with significant damage to embankment or structures where significant repairs are required and the integrity of the facility is compromised – condition appears stable with time.	1. Contact law enforcement authorities and restrict all access (except emergency responders) to dam. Restrict traffic on dam crest to essential emergency operations only.
		2. Assess extent of damage and visually inspect entire dam for additional less obvious damage. Based on inspection results, confirm if extent of damage to various components of the dam warrants revised emergency level and additional notifications.

Appendix G: Example Emergency Level – Potential Failure

Condition	Description of Condition	Action to be Taken
Sabotage and Miscellaneous Other Issues (cont.)	Criminal action with significant damage (cont.)	3. If necessary to lower reservoir level, open drain valve(s).
		4. Perform additional tasks as directed by the Dam Engineer or designee.
		5. Make notifications if conditions worsen.
Embankment Deformation	Cracks: New longitudinal (along the embankment) or transverse (across the embankment) cracks more than 6 inches deep or more than 3 inches wide or increasing with time. New concave cracks on or near the embankment crest associated with slope movement.	1. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos if camera is available. Document location on a site plan and in inspection report.
		2. Restrict traffic on dam crest to essential emergency operations only.
		3. Contact geotechnical engineer and provide all data collected.
		4. Place buttress fill (min 3 ft. high, 15 ft. wide) against base of slope immediately below surface feature and extending 20 ft. beyond visible feature limits (parallel to the embankment). Stock pile additional fill.
		5. Place sand bags as necessary around crack area to divert any storm water runoff from flowing into crack(s).
		6. Inspect the dam; collect piezometer and water level data twice daily unless otherwise instructed by engineer; and record any changes of condition. Carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement.
		7. Review information collected by field inspectors and provide additional instructions / actions as required. Consider survey monitoring.
		8. Make notifications if conditions worsen such that failure is imminent.
	Slides / Erosion: Deep slide / erosion (greater than 2 feet deep) on the embankment that may also extend beyond the embankment toe but does not encroach onto the embankment crest and appears stable with time.	1. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos if camera is available. Document location on a site plan and in inspection report.
		2. Restrict traffic on dam crest to essential emergency operations only.
		3. Contact geotechnical engineer and provide all data collected.
		4. Re-establish embankment fill slope. Place 5 ft. high buttress fill against base of slope at the slide location that extends at least 15 ft. beyond the furthest downstream limits (perpendicular to the embankment) and extending 20 ft. beyond visible feature limits at either end (parallel to the embankment).

Appendix G: Example Emergency Level – Potential Failure

Condition	Description of Condition	Action to be Taken
Embankment Deformation (cont.)	Slide / Erosion (cont.)	5. Place sand bags as necessary around slide area to divert any storm water runoff from flowing into slide(s).
		6. Inspect the dam; collect piezometer and water level data daily unless otherwise instructed by engineer; and record any changes of condition. Carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement.
		7. Review information collected by field inspectors and provide additional instructions / actions as required. Consider survey monitoring.
		8. Make notifications if conditions worsen such that failure is imminent.
	Sinkholes: Small depression observed on the embankment or within 50 feet of the embankment toe that is less than 5 feet deep and 30 feet wide or which is increasing with time.	1. Slowly open drain valve(s) to lower reservoir elevation.
		2. Measure and record feature dimensions, approximate flow rate, and relative location to existing surface features. Take photos if camera is available. Document location on a site plan and in inspection report.
		3. Restrict traffic on dam crest to essential emergency operations only.
		4. Contact geotechnical engineer and provide all data collected.
		5. Backfill the depression with relatively clean earth fill (free of organic materials) generally even with surrounding grade and slightly mounded (6 to 12 inches higher) in the center in order to shed storm water away from the depression. Stock pile additional fill.
		6. Inspect the dam; collect piezometer and water level data daily unless otherwise instructed by engineer; and record any changes of condition. Carefully observe dam for signs of depressions, seepage, sinkholes, cracking or movement.
		7. Review information collected by field inspectors and provide additional instructions / actions as required. Consider remedial construction such as grouting.
		8. Make notifications if conditions worsen such that failure is imminent.
Gate (Valve) Malfunction or Failure	Dam gates / valves damaged structurally (sabotage, debris, etc.) with uncontrolled release of water at a constant volume. Condition appears stable.	1. Close any other gates, if open.
		2. Install XXX or use other methods to stop or slow down the flow of water.
		3. Consult a structural / mechanical engineer for evaluation and recommendations. Consult dam remediation contractor for evaluation and recommendations.

Appendix G: Example Emergency Level – Potential Failure

Condition	Description of Condition	Action to be Taken
Gate (Valve) Malfunction or Failure (cont.)	Dam gates / valves (cont.)	4. Repair / replace gate / valve as necessary.
		5. Make notifications if conditions worsen such that further structural failure is imminent.
Sabotage and Miscellaneous Other Issues	Criminal action with significant damage to embankment or structures where significant repairs are required and the integrity of the facility is compromised – condition appears stable with time.	1. Contact law enforcement authorities and restrict all access (except emergency responders) to dam. Restrict traffic on dam crest to essential emergency operations only.
		2. Assess extent of damage and visually inspect entire dam for additional less obvious damage. Based on inspection results, confirm if extent of damage to various components of the dam warrants revised emergency level and additional notifications.
		3. If necessary to lower reservoir level, open drain valve(s).
		4. Perform additional tasks as directed by the Dam Engineer or designee.
		5. Make notifications if conditions worsen.

Appendix H

Exercising the Emergency Action Plan

Dam owners should exercise the Emergency Action Plan (EAP) in coordination with State, local and tribal emergency management authorities. Exercises promote prevention, preparedness, and response to incidents and emergencies and may also be extended to include recovery operations. Exercising also demonstrates the EAP's effectiveness in an actual situation and demonstrates the readiness levels of key personnel. Periodic exercises result in an improved EAP as lessons learned are incorporated into the updated EAP document.

Dam owners should include State, local and tribal emergency authorities in exercise activities. This includes, but is not limited to, entities listed on the Notification Flowchart. To facilitate the participation of emergency management authorities, dam safety exercises also can be coordinated with, or integrated into, other event exercise scenarios for earthquakes, floods, hurricanes, and other hazards.

Types of Exercises

There are seven types of exercises defined in the Homeland Security Exercise and Evaluation Program (HSEEP). Although it is not required that every exercise program include all seven exercises, the program should be built from the ground up, beginning with simple exercises and advancing to more complex exercises. Sufficient time should be provided between each exercise to learn and improve from the experiences of the previous exercise. More information on the HSEEP is available at hseep.dhs.gov.

Discussion-based Exercises

Discussion-based exercises familiarize participants with current plans, policies, agreements, and procedures, or may be used to develop new plans, policies, agreements, and procedures. The following are types of discussion-based exercises:

- **Seminar.** A seminar is an informal discussion designed to orient participants to new or updated plans, policies, or procedures (e.g., a seminar to review a new Evacuation Standard Operating Procedure). Seminars should include internal discussions as well as coordination with emergency management authorities and other organizations with a role in EAP implementation.
- **Workshop.** A workshop resembles a seminar but is used to build specific products such as a draft plan or policy. For example, a Training and Exercise Plan Workshop is used to develop a Multi-Year Training and Exercise Plan.
- **Tabletop Exercise.** A tabletop exercise involves key personnel discussing simulated scenarios in an informal setting. Tabletop exercises can be used to assess plans, policies, and procedures.
- **Games.** A game is a simulation of operations that often involves two or more teams, usually in a competitive environment, using rules, data, and procedures designed to depict an actual or assumed real-life situation.

Operations-based Exercises

Operations-based exercises validate plans, policies, agreements and procedures; clarify roles and responsibilities; and identify resource gaps in an operational environment. Types of operations-based exercises are:

- **Drill.** A drill is a coordinated, supervised activity usually employed to test a single operation or function within a single entity, such as testing sirens and warning systems, calling suppliers, checking material on hand, and conducting a call-down drill of those listed on the Notification Flowchart.
- **Functional Exercise.** A functional exercise examines and/or validates the coordination, command, and control between various multi-agency coordination centers, such as Emergency Operation Centers (EOCs) and Joint Field Offices. A functional exercise does not involve any “boots on the ground” such as first responders or emergency officials responding to an incident in real time.
- **Full-Scale Exercises.** A full-scale exercise is a multi-agency, multi-jurisdictional, multi-discipline exercise involving functional (e.g., Joint Field Office, EOC, “boots on the ground” response to a simulated event, such as activation of the EOC and role-playing to simulate an actual dam failure).

Functional and full-scale exercises are considered comprehensive exercises that provide the necessary verification, training, and practice to improve the EAP and the operational readiness and coordination efforts of all parties responsible for responding to emergencies at a dam. The basic difference between these two exercise types is that a full-scale exercise involves actual field movement and mobilization; in a functional exercise, field activity is simulated.

The primary objectives of a comprehensive exercise (functional and full-scale) are listed below:

- Reveal the strengths and weaknesses of the EAP, including specified internal actions, external notification procedures, and adequacy of other information, such as inundation maps.
- Reveal deficiencies in resources and information available to the dam owner and emergency management authorities.
- Improve coordination efforts between the dam owner and emergency management authorities. Close coordination and cooperation among all responsible parties is vital for a successful response to an actual emergency.
- Clarify the roles and responsibilities of the dam owner and emergency management authorities.
- Improve individual performance of the people who respond to the dam failure or other emergency conditions.
- Gain public recognition of the EAP.

Frequency of Exercises

The seminar, drill, tabletop exercise, and functional exercise should receive the most emphasis in an EAP exercise program. The following are recommended frequencies for these exercise types. Dam owners, in consultation with emergency management authorities, should determine actual frequencies appropriate for their dam.

- Seminars with primary emergency management authorities – annually
- Drills to test the Notification Flowchart and emergency equipment/procedures – annually
- Tabletop exercise – every 3 to 4 years or before functional exercises
- Functional exercise – every 5 years

A full-scale exercise should be considered when there is a need to evaluate actual field movement and deployment. When a full-scale exercise is conducted, safety is a major concern because of the extensive field activity. If a dam owner has the capability to conduct a full-scale exercise, a commitment should be made to schedule and conduct the entire series of exercises listed above before conducting the full-scale exercise. At least one functional exercise should be conducted before conducting a full-scale exercise. Functional and full-scale exercises also should be coordinated with other scheduled exercises, whenever possible, to share emergency management resources and reduce costs.

Evaluation of Exercises

Emergency exercises and equipment tests should be evaluated orally and in writing. Immediately after an exercise or actual emergency, an after-action review should be conducted with all involved parties to identify strengths and deficiencies in the EAP. The after-action review should focus on procedures and other information in the EAP, such as outdated telephone numbers on the Notification Flowchart, inundation maps with inaccurate information, and problems with procedures, priorities, assigned responsibilities, materials, equipment, and staff levels. The after-action review also should address the procedures that worked well and the procedures that did not work so well. Responses from all participants involved in the exercise should be considered. The after-action review should discuss and evaluate the events before, during, and after the exercise or actual emergency; actions taken by each participant; the time required to become aware of an emergency and to implement the EAP; and improvements for future emergencies.

After the after-action review has been completed, the EAP should be revised, as appropriate, and the revisions disseminated to all involved parties.

Appendix I

Example Forms and Logs

Table I-1: Example Dam Emergency Incident Log

NAME:		JOB TITLE:	
INCIDENT START DATE:		INCIDENT START TIME:	
INCIDENT DESCRIPTION:			
INITIAL INCIDENT LEVEL:			
INCIDENT DETECTION:			
When did you detect or learn about the incident?			
How did you detect or learn about the incident?			
LOG ALL NOTIFICATIONS AND ACTIVITY IN THE TABLE BELOW			
DATE	TIME	ACTION/INCIDENT PROGRESSION	ACTION TAKEN BY

Table I-2: Example Record of Plan Holders

Copy Number	Organization	Person Receiving Copy
1	Regional Dam Safety Engineer,	
2	Div. of Dam Safety Director	
3	County 24-hr. Emergency Communications Center	
4	County Coordinator of Emergency Operations	
5	Utility General Managers Office, incident command post	
6	State emergency management agency	
7	Technical Consultants / engineer	
8	DOT, Resident Engineer	

Table I-3: Example Record of Reviews and Revisions

Revision #	Date	Sections Reviewed or Revisions Made	By Whom

Table I-4: Example Dam Emergency Termination Log

DAM NAME:	COUNTY:
DAM LOCATION:	STREAM / RIVER:
DATE / TIME:	
WEATHER CONDITIONS:	
GENERAL DESCRIPTION OF EMERGENCY SITUATION:	
AREA(S) OF DAM AFFECTED:	
EXTENT OF DAMAGE TO DAM & POSSIBLE CAUSES:	
EFFECT ON DAM OPERATION:	
INITIAL RESERVOIR ELEVATION / TIME:	
MAXIMUM RESERVOIR ELEVATION / TIME:	
FINAL RESERVOIR ELEVATION / TIME:	
DESCRIPTION OF AREA FLOODED DOWNSTREAM / DAMAGE / LOSS OF LIFE:	
JUSTIFICATION FOR TERMINATION OF DAM SAFETY EMERGENCY:	
OTHER DATA AND COMMENTS:	
REPORT PREPARED BY (PRINTED NAME & SIGNATURE):	
DATE:	